

# How to determine the age of Martian ice?

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Liquid water is a necessary ingredient for any ecosystem. Here, we propose a method to determine the timing when the water on Mars got frozen. The method is based on measurements of  $^3\text{He}$  and  $^{21}\text{Ne}$  abundance in the Martian ground ice.  $^3\text{He}$  and  $^{21}\text{Ne}$  abundance is very low in the atmosphere of Mars due to the fast escape from the upper atmosphere. Liquid water would lose  $^3\text{He}$  and  $^{21}\text{Ne}$  rapidly through diffusion into the atmosphere. Therefore, background abundance of both  $^3\text{He}$  and  $^{21}\text{Ne}$  in the liquid water is very low before the freezing event. After water-freezing events  $^3\text{He}$  is produced by nuclear reactions of the cosmic rays on oxygen atoms in ice and accumulates.  $^{21}\text{Ne}$  is produced by cosmic rays on the soil particles of the permafrost (spallation reactions on Si, Al, Mg, etc), but due to fast diffusion from the small size soil particles  $^{21}\text{Ne}$  accumulates in ice also. Intensity of solar energetic particles (SEP) and galactic cosmic rays (GCR) at the surface of Mars is 100 times more than at the surface of Earth because Mars has very weak magnetic field and thin atmosphere. As a result a measurable abundance of  $^3\text{He}$  and  $^{21}\text{Ne}$  could be accumulated in ice during 1000 -10000 years.

Our method can date Martian subsurface ice as young as 1 Kyr and as old as 10 Myr. To implement this approach in the Martian missions we propose an effective method of selective He and Ne-extraction from ice followed by mass-spectrometric analysis.